FIRST REPORT

OF

EDWARD MILLER,

ENGINEER IN CHIEF

OF THE

SUNBURY AND ERIE RAIL ROAD,

TO THE

MANAGERS.

January 12, 1839.

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1839.

At a Meeting of the President and Managers of the Sunbury and Erie Rail Road Company, held on the 31st day of January, 1839, at the Philadelphia Exchange, it was, on motion of Wm. B. Reed, Esq.,

"*Resolved*, That the Board have heard with great satisfaction the able and clear Report of the Engineer in Chief, and that he is hereby directed, when the proper season arrives, to recommence field operations, with a single party of sufficient strength to complete the whole of the instrumental examinations which he deems necessary, preliminary to the location of the road west of the mouth of Sinnemahoning; and when the said examinations are finished, to commence the location of that portion of the route between Warren and Erie."

N. BIDDLE, *President*
Of the Sunbury and Erie Rail Road Company.

REPORT.

Gentlemen,

On presenting my first Report concerning so extensive and important a work as the Sunbury and Erie Rail Road, it appears proper that I should explain to the Managers some of the general principles, upon which I propose to locate and construct their road. The propriety of this course is more evident than formerly; because the prodigious strides which of late years have been made towards perfection in the mechanism and management of rail roads, have too often excited the naturally ardent imaginations of our countrymen, until misled by the prejudiced and partial statements of ignorant and interested schemers, they have closed their eyes to the plain truths of science, and leapt to conclusions which cannot fail to be disastrous as they are unfounded. Among the most erroneous of these conclusions may be noticed two, which have extensively prevailed. First, that steep grades are no longer objectionable upon rail roads, because locomotive engines have been constructed which are able to ascend them; and secondly, that locomotive power is so vastly superior to any other, that in order to attain such an inclination as is practicable for its use, almost any addition to the length of the line is admissible. The former of these notions is, of course, adopted only by those who are not conversant with the truths of mechanical science; the latter, I am sorry to say, is held or at least acted upon by professional engineers, and both I conceive to be equally heretical.

The best answer to the first of these doctrines, will be found in an Appendix to this Report, on the performance of locomotive engines. It is there shown, that an engine can draw upon a level, twice as much as upon an ascending grade of 17

feet per mile, and three times as much as on an ascent of 35 feet per mile, and that a rise of only one foot in a mile, if continued for such a distance as to overcome the momentum, will cause a reduction in the load of one-twentieth.

It was unnecessary for us to institute a regular survey of the route of the proposed rail road, in order to satisfy ourselves of the possibility of constructing a road with grades not exceeding 50, 40, or even 30 feet per mile, from the eastern to the western waters, and without inclined planes. We knew, approximately, the heights of the summits to be encountered, and we knew also, that by adopting, at any of the sources of the Sinnemahoning or West Branch, even the lightest of these grades, and steadily continuing it, winding into all the ravines and valleys which we met, and returning on the opposite side of these valleys, after reaching the points where our grade struck the bottom, we should at length meet the flats of the West Branch, long before that noble river burst from and turned its back upon the eastern escarpment of the mighty Alleghany mountain. But we also were aware, that the ravines of this region are formidable obstacles; and that if we chose a grade much flatter than the fall of the streams, near their sources, the curvature and length of the line must be greatly increased, as well as the cost of construction. With reference to this subject, it may be remarked, that a double track of railway superstructure, made in the most approved manner, will cost, exclusive of graduation, $19,000 per mile; and where the trade is considerable, we may calculate upon $600 per mile being spent annually in repairs, equal to a capital of $10,000 more. If then we estimate the cost of graduation at $11,000, (a moderate allowance for such a region,) we have a tax equal to the interest of $40,000 per annum, for every mile uselessly constructed, which must be added to the tolls, even though the cost of transportation should remain unaltered. This tax is so severe, that it will often be found cheaper to adopt inclined planes and stationary engines, than to avoid them by what is technically called "losing distance." I am perfectly aware of the numerous objections made to inclined planes by the travelling

portion of the community, many of which are well founded, though exaggerated. I know, too, that it is good policy to respect public opinions, and even public prejudices, when this can be done without too much sacrifice; and that the judicious engineer will always prefer, on a road intended for general trade and travel, a route unobstructed by inclines, even when their avoidance involves some increased cost, both in the construction and working of the road. But it must also be remembered, that although inclined planes are evils, limiting the amount of trade, and causing delay and inconvenience, yet they are not the worst features that a rail road can possess. Excessive grades and curvatures may be more dangerous, and excessive length may cause more delay, and much greater expense, both in construction, annual repairs, and transportation. When, therefore, we find engineers of acknowledged reputation, recommending for works of an important character, long continuous grades of sixty to a hundred feet per mile, and congratulating the public on the happy combination of circumstances, which has enabled them to obtain such favourable rates of acclivity; it is difficult to avoid an inquiry into particulars, before we admit that just reasons exist for congratulations. It becomes still more difficult, when we are aware, that distance appears to have been disregarded, when compared with the importance of obtaining such *low grades.* Fortunately, however, no such circumstances exist with regard to the Sunbury and Erie Rail Road; on one of the routes examined, much lower rates of acclivity having been found necessary, and this without the necessity of doubling the road upon itself, in order to increase distance, or adopting stationary power.

Our surveys were commenced on the 19th of April last. For the sake of convenience, and rapidity of examination, the corps was divided into two principal parties, under the immediate charge of my senior assistants, Messrs. Thos. J. Power, and George E. Hoffman; my own time being occupied in superintending the operations of the parties alternately, and partly in reconnoissances. The doubtful ground in the

vicinity of the sources of the Allegheny and Sinnemahoning, furnished the first field for our operations, which, in this region, covered a very extensive range of country, most of which is yet in a state of nature, clothed with dense forests, and destitute alike of roads, houses, and inhabitants. For some months on these explorations, we were compelled to give up our tents, (as pack-horses formed our only means of conveyance,) and to construct rude huts of hemlock bark and boughs, to protect us from the weather; while, at times, our only dependence for food was upon the success of the hunters accompanying our corps. Although the season was uncommonly favourable, the unavoidable hardships and privations of the members of the corps were of a very unusual character; and it gives me much pleasure, thus publicly to acknowledge, how greatly I am indebted to them for the perseverance, intelligence, and fidelity with which they have performed their duties.

The western surveys, including those on the west fork of Clarion, Teonista, Kenjua, Brokenstraw, French creek, and a portion of the crest line traced between the waters of Potato and Marvin creeks on the north, and Clarion on the south, extending eastward to the Smithport and Milesboro' turnpike, were made by Mr. Hoffman's party. The aggregate lengths of the lines traced by this party, on which levels were taken, exceeds 240 miles.

The eastern surveys, including all those on the Susquehanna and Sinnemahoning waters, Elk creek, the main Clarion, Marvin creek, Potato creek, and the Allegheny river, from the mouth of Potato creek to its source, were made by Mr. Power's party. The aggregate of his lines, upon which levels were taken, exceeds 244 miles.

The whole amount of lines traced by both parties, exceeds 484 miles, exclusive of 421 miles additional, upon which levels were not taken. Total, 905 miles.

As our surveys were of a more full and accurate character, than is customary upon a mere exploration, it may not be considered amiss to describe the general mode of operations,

particularly, as I ask of the Managers full faith in the gratifying and unexpected results, which our examinations have developed.

Each party consisted of about twenty-five persons—A senior assistant; a junior assistant, with the transit instrument: one with the level; one with the compass and slope instrument: and a draughtsman, whose duty it was to make a correct plot of the surveys, as fast as they progressed, and to take the topography of the country. The remainder of the party consisted of rodmen, chain-men, axe-men, commissary, cook, &c.

In the examination of a valley, the transit instrument preceded the others, tracing a main base line through the flats, if any existed, and leaving regular station stakes, at equal distances of 300 feet each. The level followed, taking the form of the ground, and the elevation at each station, and the compass succeeded, making lateral surveys across the valley, so as to give its entire configuration, tracing the courses of ravines, taking the slopes of hills, &c. The draughtsman collated the information thus obtained, and plotting the surveys, sketched the topography while fresh in his recollection. Our surveys and levels coincided, in a very satisfactory manner; and the maps, profiles, and records, which are now progressing under my direction, will contain a vast amount of accurate information, of the highest value to the state, in a geographical point of view; for in this region, as in every other which I have explored in Pennsylvania, the existing maps are so incorrect, as to be almost valueless.

Many conflicting opinions were entertained on the subject of the proper route; and as neither the Board nor myself had the slightest bias in favour of any course, except that which, on mature deliberation, should appear to offer the greatest advantages to the state of Pennsylvania, and her commercial metropolis, it was deemed expedient that all the lines proposed, which appeared feasible, should receive consideration, and, as far as time allowed, examination. I will also add, and I trust that the Board will concur with me in opinion, that where important interests were involved in the decision, and

particularly when the opinions of *other engineers* had been called in to strengthen those interests, it appeared to me peculiarly proper, that my examinations should be of such a character, as to put an end to speculative opinions on the subject.

It was the wish of the Board, that I should keep in mind the connexion between our rail road and the proposed branch to Pittsburgh, for the continuation of which a company has been incorporated; and, with a view to this, it was suggested that it might be found advisable to construct the main stem in the valley of either the Mahoning, Red Bank, or Clarion, making the point of divergence at the junction of one of those streams with the Allegheny river.

This is the first important matter to be considered, and is readily disposed of.

1. The distance by the shortest of our lines, without inclined planes, from Sunbury to Erie, is 283 miles; and a branch to Pittsburgh, leaving the main line on Elk creek, would be about 160 miles in length.

2. If this branch diverged at the forks of Sinnemahoning, and passed to Pittsburgh, by Bennett's branch, Sandy Lick, and Allegheny river, its length would be 178 miles.

3. The distance from Sunbury to Erie, by a line passing down the Clarion to its mouth, and thence by the Allegheny river and French creek, to Erie, will be 362 miles;—and a branch from it, at the mouth of Clarion to Pittsburgh, 82 miles.

4. The distance from Sunbury to Erie, by a line passing down Sandy Lick and Red Bank, to the Allegheny; and thence by French creek to Erie, will be 367 miles; and a branch from it, diverging at the mouth of Red Bank, will be 65 miles long.

From these facts we have the following table :

Number of route.	Distance in miles from Sunbury to Erie.	Distance from Sunbury to Pittsburgh.	Miles of Rail Road to be constructed.
1	283.	322.	443.
2	283.	295.	461.
3	362.	322.	444.
4	367.	295.	432.

The distances, as given above, when they are not taken from the results of our own examinations, are principally derived from the surveys made for the Pennsylvania Canal; and are conclusive against the adoption of a southern route for the Erie road. By passing down the Clarion, or Red Bank, to the Allegheny, and diverging thence, north and south, we should lose about eighty miles of distance in the road to Erie, without any corresponding gain in the aggregate quantity to be constructed.

This matter being disposed of, we may proceed to the comparison of the northern routes. Those most strongly urged were three in number; all of which correspond with each other, between Jersey Shore and Sunbury, and also between Warren and Erie.

No. 1. Leaves the west branch of the Susquehanna near Jersey Shore, and passes up the valley of Pine creek to its source, which interlocks with the Allegheny and Genesee rivers, in Potter county, Pennsylvania; thence down the Allegheny river to the mouth of Potato creek; up the valley of the latter stream to the mouth of Marvin creek; up Marvin creek to its source with the Kenjua; and down the Kenjua to the Allegheny river, which is intersected 12 miles above Warren. Of this route 54 miles, extending from Jersey Shore

to the Big Meadows, were located in 1836, by Mr. A Hovey, C. E., who also made a reconnoissance of the additional portion as far as Warren; and, in his published report, expresses himself thus decidedly in its favour. "The route above described, for the construction of a rail road, is more direct, cheaper of construction, more feasible, and more advantageous to the state than any other route by which Philadelphia and Erie harbour can be connected."

I have deemed it necessary to quote Mr. H's report, in order to show my reasons for making an examination so circuitous and inferior to some of the other lines examined. The length of this route, from Jersey Shore to Warren, is not less than 180 miles, and the amount of rise and fall to be encountered, 4518 feet. The summit at the head of Pine creek, as will be seen by a reference to the tabular statement at the end of this report, is higher than any one hitherto ascertained at any of the heads of the West Branch of the Susquehanna. Unless a much longer and more circuitous course than the valleys indicate be adopted, inclined planes will be advisable on Pine creek, Marvin creek, and the head branch of the Allegheny river. Our survey of this line commenced at Coudersport, the county town of Potter county, and was carried eastwardly to the head of Pine creek, and westwardly through Smithport, the county town of M'Kean, to the head of Marvin, where a connexion was afterwards made with the line traced up the valley of the Kenjua. The space between the Big Meadows and the Pine creek summit was not examined, except near the summit, for I deemed the ascertained features of the route so unfavourable as to render further explorations unnecessary.

The following table exhibits the general features of the ground upon this route.

	Distance in Miles.	Total Distance.	Rise in feet.	Fall in feet.	Total Rise and Fall.
Jersey Shore to Big Meadows, -	54.4	54.40	607.		607.
To Pine creek summit, - -	27.	81.40	1200.		1807.
To Coudersport, - - - - -	10.56	91.96		681.	2488.
To mouth Portage branch of Allegheny river, - - - - -	16.75	108.71		183.	2671.
To mouth of Potato creek, - -	10.40	119.11		35.	2706.
To Smithport, - - - - -	8.46	127.57	49.		2755.
To Marvin creek summit, - -	15.52	143.09	735.		3490.
To mouth of Kenjua, - -	25.90	168.99		980.	4470.
To Warren, - - - - - -	11.36	180.35		48.	4518.

No. 2. The second line examined, passes up the west branch of the Susquehanna to the Sinnemahoning, and up the latter stream, and its Driftwood branch, to a point designated upon the large map of Pennsylvania, as Emporium. Here it leaves the main valley, and passes up the Portage branch of the Sinnemahoning, to a summit between this stream, and the Portage branch of the Allegheny; down which the line continues to its confluence with the main river at Port Allegheny, or Canoe Place. From this point westward, the course coincides with the Pine creek route. It will require inclined planes, or a lengthened and circuitous route on the Portage branch of the Sinnemahoning, and Marvin creek. The Portage summit was designated by Colonel S. H. Long, in 1826, as the proper point at which a national turnpike or rail road from Washington to Buffalo, should pass the dividing ground between the Susquehanna and Allegheny rivers. It had been examined by Mr. Wm. Wilson, in 1827, with reference to a canal; and was recommended from many quarters, and generally conceded to be the lowest summit in that vicinity. This our surveys have confirmed. It is the lowest summit we have found between the waters of the Allegheny and Susquehanna, north of West creek. This route is rather shorter than that by way of Pine creek, and has 862 feet less aggregate rise and fall.

The following table exhibits the general features of the ground:

	Distance in Miles.	Total Distance.	Rise in feet.	Fall in feet.	Total Rise and Fall.
Jersey Shore to Emporium, - -	82.33	82.33	486		486.
Emporium to Portage summit, -	13.63	95.96	890.		1376.
Portage summit to Canoe place, -	11.48	107.44		433.	1809.
Canoe place to Warren, as before,	71.64	179.08	784.	1063.	3656.

No. 3. The next route in order, continues up the main Driftwood to its head, and then passes over an undulating country for 20 miles, between the heads of Potato creek and Marvin creek on the north, and the sources of the Clarion river on the south, to the summit between the head of the south fork of the Kenjua and Marvin creek. From this point westward, it corresponds with the two preceding lines. This is the shortest route practicable, between Sunbury and Erie. It will require two inclined planes on the Driftwood, near its head; this stream falling 500 feet in 2½ miles. On the Kenjua, a grade of 52.80 feet per mile will be necessary for several miles, and there will be a similar one on the Driftwood, below the second inclined plane.

The following table shows the general features of the ground:

	Distance in Miles.	Total Distance.	Rise in feet.	Fall in feet.	Total Rise and Fall.
Jersey Shore to Emporium, - -	82.33	82.33	486.		486.
Emporium to Driftwood summit, -	16.	98.33	1198.		1684.
Driftwood to head of Potato creek and Clarion, - - - - -	8.86	107.19		121.	1805.
Thence to Kenjua and Marvin summit, - - - - - -	10.	117.19	129.		1934.
Thence to mouth of Kenjua, -	25.90	143.09		980.	2914.
Thence to Warren, - - -	11.36	154.45		48.	2962.

This route is 25 miles shorter than either the Pine creek or the Portage route. It has 1556 feet less rise and fall than the former, and 694 feet less than the latter.

Route No. 4, occupies an intermediate position between the northern and southern routes, so called; and is the only one we have examined upon which I think that inclined planes

may, with propriety, be dispensed with. It leaves the second and third lines, above described, near Emporium, and joins them again near Warren, on the Allegheny river. On account of its admitting locomotive power throughout, to advantage, I shall describe it as a portion of the main line, although there may be a doubt whether, on a careful comparison, No. 3 (which may, with the reductions consequent on an ultimate location, probably prove to be somewhat shorter, and to have about 100 feet less rise and fall) may not come into competition with it. The early date at which it is necessary for me to report, renders it impossible for me to have a full comparison from all the data made out, and I have therefore selected that which appeared to possess the most promising features.

I have already stated that all the lines examined during the past season, coincide between Warren and Erie, and also between Sunbury and Jersey shore. From Sunbury to Jersey shore the only question concerning the location, will be with reference to the side of the river which the road shall occupy.

Our eastern surveys terminated at Lock Haven, near the mouth of Bald Eagle creek; the weather having set in so severely as to prevent us from proceeding further than that point. From Lock Haven to the mouth of the Driftwood, our line was traced wholly upon the southern bank; the canal (already partly constructed or in progress, and the remainder located), occupying the northern side, which would otherwise be more favourable, in such a manner as to make the difficulty of constructing a road there very great. Throughout nearly the whole of this distance, the river runs through high mountains, and the bottoms are narrow and of limited extent. Below Lock Haven the flats are wide, and there generally would be room enough for both works. In some places, however, and I may mention especially the well known Muncy Hills, and Larry's Bluffs, there would be very great difficulty in constructing the road; and it would be almost impracticable to do so without serious interference with the navigation of the canal. In other positions the rail road would be driven

from its proper course by the serpentine character of the canal, or forced to cross it, at the cost of an additional summit, and expensive embankments.

These circumstances make it proper that a careful examination of the southern bank of the river should be made, and that the company should have permission to occupy that side, throughout the whole course of the valley, if it should prove the most favourable. The road may be connected with Williamsport, (a point named in the company's charter,) by a bridge across the Susquehanna; which will accommodate the trade of the town, and also form a junction with the Williamsport and Elmira Rail Road, now in process of construction.

The bridge now building at Jersey Shore, may form the connexion with the proposed Willardsburg and Jersey Shore Rail Road, which is to pass up Pine creek; and at Lock Haven, the Bald Eagle and Spring creek navigation will be tributary to our road, being on the same side of the Susquehanna.

If the southern side of the river be adopted for our line, I am not aware that any difficulties will be encountered between Lock Haven and Sunbury, except those of an ordinary character. In some places bluffs occur which are washed by the river, but they are not numerous, nor of great extent. A bridge will be required across the north branch of the Susquehanna at Northumberland, one across the West Branch between that place and the Muncy Hills; and another across the same stream for the Williamsport branch. There is, in the whole distance, no large tributary of the West Branch to be crossed, except Bald Eagle creek;—distance 63 miles.

From Lock Haven to the mouth of the Sinnemahoning, the distance is 39½ miles; and of this, 14¼ miles are along bluffs washed by the river. The remainder is through narrow bottoms, and is easy of construction. The West Branch is crossed at the mouth of the Sinnemahoning, but no other bridge of consequence will be required.

The Sinnemahoning, from its confluence with the Susquehanna to the mouth of the Driftwood branch, offers similar

difficulties with the previous section upon the main river, though of less moment, as the floods are of less height.—Distance 15.33 miles, of which five are bluffs.—The only bridge of importance is that across Bennett's Branch.

The Driftwood is a crooked stream, winding among the mountains, and presenting alternate flats and bluffs; each loop of the stream having a flat within it, and washing a steep bluff on the opposite side of the bend. In order to make a good and cheap line on this portion of the route, it will be necessary to cross the stream six times by bridges. At one of the worst bends, a tunnel, 2100 feet long, will be required; this will save 1½ miles of distance, and some very bad curvatures.

The distance from the mouth of Driftwood to the mouth of West creek is 17½ miles.

Along West creek, the line is highly favourable, except about six miles, near the summit, on which, however, no serious difficulty occurs. The distance is 18½ miles.

A critical examination of the summits between the West and Elk creek waters, followed by a crest line, which was traced for about six miles between the sources of Elk creek on the west, and Trout run and West creek on the east, made known a new summit, 38 feet lower than that discovered by Mr. Wilson in 1825, which has hitherto been considered the lowest in this region. I propose to reduce this summit 18 feet by a cut, which will bring it nearly to a level with the waters of Beaver run, a tributary of Elk creek. The line then passes down Elk creek to Jacobs' mill, about one mile above Ridgeway, which is near the confluence of Elk creek and Clarion river. At this point a branch to Pittsburgh might diverge, which would be about 160 miles long, descending the whole distance, and probably having no grade exceeding ten feet per mile, except one mile at the upper end, on which it might be as much as twenty feet. Elk creek enters the Clarion at a very acute angle, and at Jacobs' mill, the streams approach so near to each other, that a tunnel through the neck of land separating the valleys, which will save 2½ miles of distance and some very abrupt curvatures, will only be 2,200 feet

in length. The distance from the summit to the north end of the tunnel, is $11\frac{1}{4}$ miles. Generally favourable. The main line then passes up the valley of the Clarion to Johnsonburg or Coopersport, which is situated at the forks of the Clarion; it there takes the west fork, and continues up it to its extreme head; which rises near the south branch of the Teonista, 13 miles from Johnsonburg. The lowest summit between these streams is reduced 92 feet, by a tunnel 2500 feet long, and the line then continues along the northern slope of the hills, skirting the valley of the Teonista, descending by a regular graduation, until it strikes the bottom of the valley, $11\frac{1}{4}$ miles from the summit. From this point the road will occupy the flats and gently sloping ground on the north side of the Teonista valley for $14\frac{1}{3}$ miles to the Cranberry swamp, from which the water flows into the Teonista, and also into Morrison's run, a small brook emptying into the Allegheny river two miles above Warren. Four large bridges, and several high embankments will be required to pass the deep ravines which are made by the small streams emptying into the west fork of the Clarion, and the south fork of the Teonista, and a part of the road along these streams will be constructed on steep hill sides. Along the main Clarion, no peculiar difficulties occur; and through the Teonista valley, for 14 miles, the character of the line will be highly favourable, and the expense of construction very moderate.

From the Cranberry swamp to a point near Warren, $4\frac{3}{4}$ miles, the line descends along the slope of the river hill, and will be somewhat expensive, until it strikes the bottoms. It then passes along the valley of the Allegheny river, which is crossed by a bridge near Warren, and continues its course to the mouth of the Brokenstraw; thence up the valley of the latter stream, and its tributary, Hare's creek, to a summit between the latter stream and Miles' branch of French creek. The line then is continued down this stream to Big French creek, the valley of which is followed for three miles, and then strikes across to Le Bœuff creek, near Waterford, and from this point is nearly a direct line to the Le Bœuff summit, at the head of

Walnut creek, a tributary of Lake Erie. The distance from the point where the road strikes the Allegheny river to the Le Bœuff summit, is 54½ miles; and the whole of it is highly favourable with respect to graduation and curvature, and generally very easy of construction.

From this summit to Erie, several lines were traced, but the season was so far advanced, and so inclement, as to preclude us from giving it the full attention which its intricacy requires. I wish also to give more consideration to the important questions growing out of a connexion with the town and harbour, than my employments have hitherto permitted; and therefore postpone expressing an opinion on the subject, until further examinations are made, only remarking that we have established the practicability of reaching the harbour with a grade of 52.80 per mile.

I have annexed a tabular statement, exhibiting, in a general view, the character of the whole line, as it will be found upon a careful location, provided no route superior to that above described shall be found. It is proper however to say, that a reconnoissance of a different branch of the Teonista, gave us reason to hope that a more favourable one, with a lower natural summit, might be found a few miles north of that which we traced. The season, however, was advancing so rapidly, that I feared we should not reach Erie before winter; and the instrumental examinations were therefore deferred until a more convenient opportunity. For the same reason, some examinations which were desired by the inhabitants of the northern part of Erie county, with reference to a route by the Little Brokenstraw, passing the village of Columbus, were postponed.

TABLE of Grades, Distances, and Elevations of the Sunbury and Erie Rail Road.

	Distance in Miles.	Total Distance from Erie.	Rise in feet.	Fall in feet.	Elevation compared with Lake Erie in feet.	Average grade in feet per Mile	Steepest grade in feet per Mile.	Total Rise and Fall.
Le Bœuff Summit,	14.00	14.	655.		+ 655.	46 79	52 80	655.
Lowest Point on Le Bœuff Creek,	4.75	18.75		30.	+ 625.	6.32	6.32	685.
French Creek and Brokenstraw Summit,	20.63	39.38	240.		+ 865.	11.63	20.00	925.
Mouth of Brokenstraw,	23.00	62.38		263.	+ 603.	11.43	15 00	1188.
Foot of Steep Grade near Warren,	6.19	68.57	30.		+ 633.	4 85	6 00	1218.
Cranberry Swamp Summit,	4.75	73 32	201.		+ 834	42.24	42 24	1419.
Forks of Teonista,	9.00	82 32		75.	+ 759.	8.33	12.00	1494.
Point on Teonista, where Steep Grade commenees,	5.34	87.66	79.		+ 838.	15.37	17.00	1573.
Teonista and Clarion Summit,	10.80	98.46	576.		+ 1414.	52.80	52.80	2149.
Summit Level,	.47	98.93						
Point on Clarion, where Steep Grade terminates,	9.60	108 53		505.	+ 909.	52.80	52 80	2654.
Lowest Point on Clarion River,	9.73	118.26		92.	+ 817.	9.42	12 00	2746.
Elk and West Creek Summit,	11.25	129.51	295.		+ 1112.	26 24	33.00	3041.
Point where Steep Grade ends,	7.00	136.51		370.	+ 742.	52.80	52.80	3411.
Mouth of West Creek,	11.50	148.01		302.	+ 441.	26.23	28.00	3712.
Mouth of Driftwood,	17.50	165 51		224.	+ 217.	12 79	14.00	3937.
Mouth of Sinnemahoning,	15.33	180.84		71.	+ 146.	4.67	7.50	4008.
Lock Haven,	39.50	220.34		164.	— 18.	4.16	12.00	4172.

Lake Erie is 565 feet above tide water; and the point where our surveys terminated, at Lock Haven, is 18 feet below Lake Erie. It is, consequently, 547 feet above tide, and 129 feet above the surface of water in the pool of Sunbury dam. The distance from Lock Haven to Sunbury will be about 63 miles; average descent, 2 feet per mile.

From this table it appears that the whole distance from Sunbury to Erie is 283 miles; that in this distance there are five natural summits; two of which, viz. Cranberry Swamp and Le Bœuff, are of very small consequence; that the total amount of rise and fall, from the surface of water in Lake Erie to the surface of water in the Sunbury dam, will be 4,301 feet, all of which may be advantageously overcome by locomotive power; that the steepest grade required is 1 in 100, or 52.80 feet per mile; and it is in no case necessary to increase the length of the line by a circuitous course, in order to obtain this rate of acclivity; that on 5-6ths of the road no grade, exceeding 33 feet per mile, will be necessary; on 3-4ths of it, none exceeding 20 feet per mile; and on 2-3ds of it, none exceeding 12 feet per mile.

The steep grades are confined to four places, and, with the exception of that at Erie, are all in positions where bituminous coal, for fuel, can be had at a very low price. Extra locomotive power may consequently be employed upon them with great advantage.

With respect to curvature, the line is generally very favourable, and the cost of construction will be moderate, compared with the character of the work, and the importance of the objects in view. Indeed, if the location were conducted upon the principles avowed by the managers of our great northern rival, the New York and Erie Rail Road, (V. Report, 1835, page 7,) and a cheap superstructure proposed, such as is recommended for a principal part of that work; the first cost of the road would be so small as to astonish every one. I trust, however, that Pennsylvania has by this time learned, that rail roads, if made at all, should be well made; and that, where a very large amount of trade and travel is anticipated, judi-

cious economy dictates that we should rather increase the original outlay, than be cursed by a perpetual and more than equivalent tax, for the increased cost of repairs and transportation, while the history of the work ever remains rife with tales of dreadful accidents and vexatious delays.

With these views, I recommend that the Sunbury and Erie Rail Road be constructed throughout in the best and most permanent manner; wide enough for a double track; and that heavy iron rails, supported upon continuous bearings of squared timbers, well bound together by wooden cross ties, be adopted.

Should the Board approve, I propose to make experiments with regard to the cheapest mode of preparing timber so as to secure it from decay; and should any mode be discovered which will fulfil this important object, without involving too great an expense, to adopt it, and make the superstructure permanent at once. Only a single track, with proper passing places, will be required in the first instance; and it will cost, on the plan I prefer, about $9,500 per mile.

In order to render the work productive, with the least practicable expense, it will be advisable to construct that portion between Erie and the mouth of the Sinnemahoning first. This section will be one hundred and eighty-one miles long, and will, with the state improvements, now completed and under contract, form a connexion between the harbour of Erie and the city of Philadelphia, in the cheapest and quickest method possible; and will thus answer the quadruple object of improving an important portion of the state; making the West Branch Canal profitable, which is now wholly unproductive; creating an immediate revenue to the stockholders of the rail road; and diverting much of the lake trade and travel to Philadelphia.

I estimate the aggregate cost of constructing this portion of the road with a single track of superstructure, inclusive of all contingencies, at $4,365,000.

The remaining section of 102 miles, lying wholly in the valley of the Susquehanna, will be parallel to the State Canal, and there is consequently less immediate call for its construction. As soon, however, as the western portion is completed,

there can be no doubt that the amount of trade created will cause an early construction of the remainder, which, with the other roads, now in progress of construction, east of Sunbury, will make a perfect railway communication between Philadelphia and Erie.

It will not, of course, be expected that an accurate estimate can be made of the cost of such a work, from the preliminary examinations alone. From as careful a calculation, however, as I am able to make from the existing data, aided by the experience I have already had in the construction of similar work, in a similar country, I am induced to believe, that in order to finish it completely, with a double track of heavy iron superstructure; including turnouts, water stations, depôts, warehouses, machine shops, land damages and engineering expenses, the sum of $9,508,800, or $33,600 per mile will be required.

One hundred passengers, carried over the road daily, in each direction, for 340 days, at a toll of 2 cents per mile; and 50,000 tons of merchandise and produce in each direction, per annum, at a toll of 2 cents per ton per mile, will pay the repairs and superintendence of the road, and yield an income of more than 8 per cent. on this investment; supposing that no profit whatever is made on transportation.

Can any one who is acquainted with the extent and resources of the immense region bordering upon our north-western lakes, suppose, for a moment, that the amount of trade and travel, which it will pour into this rail road, will not vastly exceed the amounts I have mentioned? The number of passengers carried on the Utica and Schenectady Rail Road, annually, is more than 50 per cent. greater than I have named; and this is but an isolated portion of an unfinished line, intended for the same object as that which we are considering. Let it be remembered, that when the improvements now making by the United States' government, at the western end of Erie harbour, are completed, every steamboat, bound from a port west of this point, to Dunkirk or Buffalo, will stop at Erie. This, therefore, is a point from which to calculate distances to

New York, as well as to Philadelphia; and the result is, that Philadelphia is 100 miles nearer to the trade of the north-west than New York can be, by either the New York and Erie Rail Road, or the Albany and Buffalo Rail Road. For a distance of 140 miles, the Sunbury and Erie Rail Road passes through a region abounding in bituminous coal and iron ore of admirable quality; while its northern rivals are destitute of this immense source of wealth and revenue. Nor is this all: the total amount of rise and fall, upon the New York and Erie Rail Road, is about 2,400 feet greater than that encountered between Erie and Philadelphia; and it can, therefore, never compete with the Pennsylvania route, for cheapness of transportation.

I believe that Philadelphians have never, hitherto, been aware of the value of their position with regard to the trade of the north-west, and that they have generally but little notion of the vast commercial importance of that trade now and prospectively. A northern statesman estimates that part of the lake region, contained within the United States alone, at 280,000 square miles; and adds, "It is nearly twice as large as the kingdom of France, and about six times as large as the whole of England. It contains 180 millions of acres of arable land, a large proportion of which is of surpassing fertility." Our enterprising neighbours to the north, who have hitherto enjoyed this trade exclusively, appreciate it fully. Not content with a canal of greater capacity than that of Pennsylvania, they are now engaged in increasing its dimensions threefold; and at the same time pressing forward the construction of two gigantic rail roads, aided by state influence and patronage, in order to multiply the avenues to their metropolis.

The results of the surveys of the past season sufficiently prove that a rich portion of this great trade may be directed to Philadelphia by the early completion of the Sunbury and Erie Rail Road. This will also make the village of Erie, which possesses, incomparably, the best harbour upon the lake, an important city. It will develop the mineral and agricul-

tural resources of an extensive section of Pennsylvania, which has hitherto remained a comparative wilderness; will open new avenues for our commercial and manufacturing enterprise; and form a close bond of union in addition to those already existing between the different states composing our national confederacy.

Respectfully submitted.

EDWD. MILLER, C. E.

Philadelphia, Jan. 12th, 1839.

APPENDIX.

No. 1.

The following tables exhibit the heights of nearly all the summits hitherto ascertained in Pennsylvania, between the waters flowing into Chesapeake Bay and those flowing into the Ohio river.

No. 1, shows the names of the summits in their geographical order, from north to south; the names of the engineers, upon whose authority the heights are given; and the elevations of the summits above tide-water. Most of the summits given are depressions in the mountain, much lower than its general range. The ordinary height of the Allegheny, in the vicinity of the heads of the Driftwood and Pine creeks, is about 2500 feet above tide. The highest point crossed between the Sugar Run Gap and Cedar Swamp Gap, by a crest line, 15 miles long, traced under Col. Long's directions, was 2790 feet above tide. The highest point crossed by Hother Hage, Esq. C. E., in his surveys of the past season, for a rail road from Chambersburg to Pittsburg, was 2915 feet above tide.

No. 2, shows the same summits as No. 1, arranged in the order of their elevation, with the height of each in feet, above the summit selected for the extension of the West Branch division of the Pennsylvania Canal, by Mr. Aycrigg, and originally proposed by Mr. Wilson. This is the lowest natural summit ascertained in Pennsylvania, between the eastern and western waters.

These tables have been constructed from the best data within my reach, and must be very nearly correct.

It will be noticed that our summit is only 142 feet higher than that at the head of Bennet's Branch and Sandy Lick, and that there are only three lower summits known in Pennsylvania. It will also be observed that the Blair's Gap Summit, which is that adopted for the Portage Rail Road, is the seventeenth in order; the Sand Patch, proposed for the Baltimore and Ohio Road, the nineteenth; the lowest discovered, within the range of the proposed Chambersburg and Pittsburg Rail

Road, the twenty-fifth; and that proposed for the Chesapeake and Ohio Canal, the twenty-seventh.

It must be remembered that the elevations given in the tables are those of the surface of ground, without any reference to proposed reductions.

(No. 1.)

TABLE, showing the heights above tide of Natural Summits in the Allegheny Mountain, in Pennsylvania, between the Waters flowing into the Ohio, and those flowing into Chesapeake Bay, ascertained from various Surveys made at different times, with a view to Internal Improvements.

Name of Summit.	Authority.	Height in feet above tide.
Pine Creek Summit,	E. Miller,	2330
Sinnemahoning Portage Summit,	,,	1899
Lowest Summit at head of main Driftwood,	,,	2207
South Fork of main Driftwood,	,,	2223
Lowest Summit between West Creek and Elk Creek,	,,	1696
Wilson's Summit, between West Creek and Elk Creek,	,,	1734
Summit between Trout Run and Elk Creek,	,,	1887
Flag Swamp Summit, between Little Toby and Bennet's Branch,	W. Wilson,	1874
Lowest Summit between Bennet's Branch and Sandy Lick,	,,	1554
Summit between Sandy Lick and Anderson's Creek,	B. Ayerigg,	1681
Summit between Anderson's Creek and Mahoning,	,,	1862
Summit between Mahoning and Curry's Run,	,,	1921
Clover Patch Summit,	,,	2009
Cushing and Two Lick Summit,	Jno. Mitchell,	1608
Clearfield and Conemaugh Summit,	F. Rawle,	1858
Burgoon's Gap,	C. De Hass,	2358
Sugar Run Gap,	S. H. Long,	2290
Blair's Gap,	,,	2339
Adams' Gap,	,,	2465
Laurel Gap,	,,	2512
Big Spring Gap,	,,	2594
Bob's Creek Gap,	,,	2503
Cedar Swamp Gap,	,,	2457
Chambersburg and Pittsburg Summit,	H. Hage,	2547
Sand Patch Summit,	J. Knight,	2412
Albright's Summit, between Laurel and Flagherty's Runs,	,,	2424
Summit of Chesapeake and Ohio Canal,	U. S. Engineers,	2759

(No. 2.)

TABLE, exhibiting the height of each Summit contained in the preceding Statement; that between Bennet's Branch and Sandy Lick, which is the lowest hitherto ascertained in Pennsylvania, being considered zero.

1st. Lowest Summit between Bennet's Branch and Sandy Lick,	0
2d. Cushing and Two Lick Summit,	54
3d. Summit between Sandy Lick and Anderson's Creek,	127
4th. Lowest Summit between Elk and West Creeks,	142
5th. Wilson's Summit on Elk and West Creeks,	180
6th. Clearfield and Conemaugh Summit,	304
7th. Anderson's Creek and Mahoning,	308
8th. Flag Swamp Summit, between Little Toby and Bennet's Branch,	320
9th. Summit between Trout Run and Elk Creek,	333
10th. Sinnemahoning Portage Summit,	345
11th. Summit between Mahoning and Curry's Run,	367
12th. Clover Patch Summit,	455
13th. Lowest Summit at head of main Driftwood,	653
14th. South Fork of main Driftwood,	669
15th. Sugar Run Gap,	736
16th. Pine Creek Summit,	776
17th. Blair's Gap,	785
18th. Burgoon's Gap,	804
19th. Sand Patch Summit,	858
20th. Albright's Summit, between Laurel Run and Flagherty's Run,	870
21st. Cedar Swamp Gap,	903
22d. Adams' Gap,	911
23d. Bob's Creek Gap,	949
24th. Laurel Gap,	958
25th. Chambersburg and Pittsburgh Summit,	993
26th. Big Spring Gap,	1040
27th. Summit of Chesapeake and Ohio Canal,	1205

APPENDIX.—No. 2.

Power of Locomotive Engines.

It appears, from the numerous and careful experiments made upon the Liverpool and Manchester Rail Road, by Chevalier de Pambour, that the friction of locomotive engines, without loads, is equal to 15 lbs. per ton; that the friction of cars in trains, is equal to 8 lbs. per ton; and that an additional friction of 1 lb. is caused in the engine by every ton weight of the load drawn.

From these data, we can calculate the power exerted by a locomotive, when we are acquainted with its load on a level, or upon any known acclivity. And having obtained the power, we can deduce its load upon any required grade.

Let W = weight of locomotive in tons.
„ W′ = „ tender and train in tons.
„ D = „ distance in feet, in which road rises 1 foot.
„ P = „ power or exertion of locomotive in lbs.

Then,

1. To ascertain the power or exertion of the engine, when we know the load it can take on a level.

$$P = 15\ W + 9\ W'$$

2. To ascertain the power of the engine, when we know the load it can take on any given ascending grade.

$$P = 15\ W + 9\ W' + 2520\left(\frac{W + W'}{D}\right)$$

3. To ascertain the load an engine will draw upon a level, the power being known.

$$W' = \frac{P - 15\ W}{9}$$

4. To ascertain the load an engine will take up any given grade. The power in lbs. being known from one of the preceding formulæ.

$$W' = \frac{PD - 15\ WD - 2520\ W}{9\ D + 2520}$$

The superintendent of the Columbia Rail Road, in his report to the Canal Commissioners of Pennsylvania, for 1837, uses the following language with relation to the performance of engines

upon that road. Vide Canal Commissioners' Report, 1837, page 51. "The heavy locomotives now used for the transportation of freight, are capable of drawing thirty-five cars, each with a load of three tons; or one hundred and five tons, exclusive of the cars, engine and tender. If their weight be added, the whole will be one hundred and ninety tons, over a road with only one short level, and with grades running up to fifty feet per mile." And the state engineer having charge of the same work, says, in the same Report, page 43. "The Columbia and Philadelphia Rail Road is capable of passing almost an infinite amount of business. The heavy engines working upon it, will take each thirty loaded cars over the road at a time, being a gross load of one hundred and sixty-five tons, exclusive of the engine and tender, performing one trip a day, or seventy-seven miles. Some of the engines have made their regular daily trip, throughout the season, without scarcely a dollar of repairs." And on page 44, the same gentleman says: "Engines have passed over the road, as an extraordinary performance, with trains of thirty-five loaded burthen cars each, and passed the high grades without difficulty."

It must be remembered, that on the above mentioned road, there is a continuous grade of thirty-feet per mile, for several miles; passing near the Gap ridge, into another of forty-five feet per mile, for about three-fourths of a mile. I have seen these grades stated much higher, but believe this to be correct.

The heavy engines on this road, weigh about nine tons, and the tenders about five tons, with fuel and water; and we may safely conclude, that the engine which was able to encounter the long grade of thirty feet, passing into forty-five, was working under its power on the lighter grade. The curves on this road are known to be numerous and abrupt, and its character generally unfavourable.

Let us assume, then, the performance of an engine on this road to have been equal to 190 tons gross, including engine and tender, taken up a grade of 30 feet per mile, or 1 in 176. —We have then,

$$W = 9;\ W' = 181;\ \text{and}\ D = 176$$

And, consequently, from the second formula,

$$P = 135 + 1629 + 2520\frac{190}{176} = 4484 \text{ lbs.}$$

And from the third formula, we have

$$W' = \frac{4484 - 135}{9} = 483 \text{ tons.}$$

From which it appears that this engine exerted a force equal to 4484 lbs., and that it was capable of drawing 483 tons, exclusive of the weight of the engine, upon a level road.

When mud, frost or dew is upon the rails, the adhesion of the driving wheels is materially diminished, and I prefer, therefore, in the following table, assuming the weight of the engine at 10 tons, with its fuel and water, and the gross load on a level, exclusive of the engine, at 300 tons. This will give by the first formula, 2850 lbs. as the power of the locomotive.

Such an engine will be able to ascend an inclined plane, rising 1 foot in $9\frac{1}{3}$ feet, equal to an inclination of 6° 9′ 2″, without any load whatever. On a grade of 17.68 feet per mile, or 1 in 298.67, its load will be reduced one-half. On a grade of 52.8 per mile, or one foot rise in 100, the load due to it will be $71\frac{1}{2}$ tons. This last, it will be remembered, is the steepest grade required on the Sunbury and Erie Rail Road. A reference to this table and to the preceding one, exhibiting the general character of the route, will show what loads can be taken over any required portion of the road.

It is proper to remark, that Mr. William Norris, of Philadelphia, well known as a manufacturer of locomotive engines, is willing to guarantee that those constructed by him of the weight used in the preceding calculation, viz. 10 tons, will draw as their minimum load in moist weather, upon a level rail road, 387 tons. This is 29 per cent. greater than the amount used in the table.

To calculate the following table, we have in the fourth formula $P = 2850$ $W = 10$. Then substituting these values and reducing the equation to its simplest form,

$$W' = \frac{300\,D - 2800}{D + 280}$$

Tabular Statement, exhibiting the Gross Load, in Tons, exclusive of the weight of the Engine, which a Locomotive, weighing 10 *tons, and capable of drawing* 300 *tons on a level Rail Road, is able to take up different rates of acclivity.*

Value of D. or distance in feet, in which the road rises one foot.	Ascent in 100 feet, in feet, corresponding with D.	Ascent per mile in feet.	Value of W. or gross weight of load, exclusive of Engine, in tons.	Value of D. in feet.	Ascent in 100 feet in feet.	Ascent per mile in feet.	Value of W. in tons.
10	10.	528.	.690	270	.37	19.555	142.182
20	5.	264.	10.667	280	.357	18.857	145.
30	3.333	176.	20.	290	.345	18.207	147.719
40	2.5	132.	28.75	300	.333	17.6	150.345
50	2.	105.6	36.970	310	.322	17.032	152.881
60	1.667	88.	44.706	320	.312	16.5	155.333
70	1.429	75.429	52.	330	.303	16.	157.704
80	1.25	66.	58.889	340	.294	15.529	160.
90	1.111	58.667	65.405	350	.286	15.086	162 222
100	1.	52.80	71.579	360	.278	14.667	164.375
110	.909	48.	77.436	370	.270	14.270	166.461
120	.833	44.	83.	380	.263	13.895	168.485
130	.769	40 615	88.293	390	.256	13.538	170.447
140	.714	37.714	93.333	400	.25	13.2	172.353
150	.667	35.2	98.139	500	.2	10.56	188.717
160	.625	33.	102.727	600	.167	8.8	201.364
170	.588	31.059	107.111	700	.143	7.543	211.428
180	.555	29.333	111.304	800	.125	6.6	219.630
190	.526	27.789	115.319	900	.111	5.867	226.44
200	.5	26.4	119.167	1000	.1	5.28	232.187
210	.476	25.143	122.857	2000	.05	2.64	261.930
220	.454	24.	126.4	3000	.033	1.76	273.537
230	.435	22.956	129.804	4000	.025	1.32	279.796
240	.417	22.	133.077	5000	.020	1.056	283.56
250	.4	21.12	136.226	5280	.019	1.	284.388
260	.385	20.307	139.259	Level.			300.